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Effect of Two Stages Adsorption as Pre-Treatment of Natural Organic Matter Removal in Ultrafiltration Process for Peat Water Treatment

Mahmud[2,a], Muthia Elma[1,3b*], Erdina Lulu Atika Rampun[1,3c], Aulia Rahma[1,3d], Amalia Enggar Pratiwi[1,3e] , Chairul Abdi[2,f], Raisa Rossadi[2,g]

[1]Chemical Engineering Department, Faculty of Engineering, Lambung Mangkurat University, Banjarbaru, 70714, Indonesia

[2]Environmental Engineering Department, Faculty of Engineering, Lambung Mangkurat University, Banjarbaru, 70714, Indonesia

[3]Material and Membrane Research Group (M[2]ReG), Lambung Mangkurat University, Banjarbaru, 70714, Indonesia

[a]Mahmud@ulm.ac.id, *[b]melma@ulm.ac.id , [c]elarampun@mhs.ulm.ac.id, [d]arahma@mhs.ulm.ac.id [e]aepratiwi@mhs.ulm.ac.id, [f]chairulabdi@ulm.ac.id, [g]raissa.rosadi@gmail.com

Keywords: Adsorption, natural organic matter, fouling, pretreatment, ultrafiltration

Abstract. Natural Organic Matter (NOM) content in peat water is a major problem of membrane fouling in ultrafiltration (UF). For that, two stages adsorption as pre-treatment was employed to minimize the membrane fouling of NOM content. This research was carried out to investigate the effect of two stages adsorption on ultrafiltration performance for NOM removal that remains in peat water. This method was using powdered activated carbon (PAC) dosage of 80, 160, 240, 320, 400, 480, 560, 640, 720, 800, 880 dan 960 mg.L^{-1}. Then, Polysulfone (Psf) material was employed for Ultra filtration process. Membrane was applied in a dead-end mode with various operating pressure (1; 1.5; 2; 2.5; 3 bar). As a results, the optimum dose of PAC was 800 mg L-1 with dosage ratio of 3/4:1/4. Two stages adsorption-UF PSf provided the range from 86.9 to 92.8% of $KMnO_4$ and 74.1-88.1% of UV_{254}. For the experimental condition of 3 bar, the highest flux was achieved up to 39.919 L h^{-1}.m^{-2}.

Introduction

Peat water is stored in a peatland and can be found in temperate zone. Amount of natural organic matter (NOM) is present in peat water include humic acid and acidic as well [1]. In general, NOM can be divided into three fraction: hydrophobic (dissolved organic carbon with larger molecular weight), hydrophilic (smaller molecular weight such as: polysaccharides, amino acid, protein and etc) and transphilic (molecular weight between hydrophobic and hydrophilic) [2, 3]. Hence, it is important to treat a peat water.

Ultrafiltration (UF) is an alternative technology to improve water quality [4]. Nevertheless, membrane fouling is still unavoidable problem [5, 6]. Fouling is occurred when foulant deposit on membrane surface or block the pore. It can make a flux drop and lowered membrane performance. In a previous study shows NOM can cause fouling in UF membrane. Although hydrophilic fractions have less impact on water quality, but studies show large size molecules of hydrophilic NOM have greatly main contribute to fouling [7]. Many methods have been reported to minimize the fouling such as photocatalytic [8], oxidation and ozonation [9], coagulation-flocculation [10], and adsorption [11]. Among them, adsorption using activated carbon good to removes hydrophilic NOM [12, 13].

Adsorption of NOM by activated carbon can be pre-treatment [14]. To increase efficiency of NOM adsorption, two stage adsorption using powdered activated carbon (PAC) can be applied. Two stage adsorption process worked by divided adsorbent capability to transfer adsorbate to adsorbent surface itself. It would maximize efficiency removal and required lower dosage rather than one stage adsorption [15]. However, some researches still have pros and cons about PAC effect on membrane fouling Tansakul, Laborie and Cabassud [16] and Campinas and Rosa [17] have investigated PAC as pre-treatment reduce membrane fouling which caused by NOM. In other hand, many researches also found different results. Combination between PAC and NOM lead to membrane fouling more severe [18-20].

Polysulfone has choosen as polymer because it have highly strength structure on high temperature and chemical resistant [21]. But polysulfone membrane has hydrophobic properties and vulnerable to NOM fouling [22, 23]. So, PEG additive is added to enhance membrane selectivity [24] . Several studies have treat peat water using cellulose acetate [25, 26] and polysulfone membrane [27-29].
In the present work, two stage adsorption with PAC as pre-treatment is carried out to investigated it is the effect on UF PSf performance. Flat sheet of UF membranes were varied at 1-3 bar. Further, $KMnO_4$ and UV_{254} rejection are determined to represent organic and NOM.

Materials and Methods

Materials. A peat water was collected in KM 17 Banjar regency, South Kalimantan. Polysulfone (Merck), N,N-dimethylacetamide (DMAc) (Merck), Polyethylene Glycol 600 (Merck), KCL 0.5% (Merck), acetone 70% (Merck), H2SO4, NaOH (Emsure), oxalic acid (Merck), aquadest, and PAC (Merck), TOC analyzer (Shimidzu), UV-vis, pH meter (Hanna).

UF membrane synthesis. Thin film were prepared using phase inversion technique. Firstly, 64% by weight of DMAc was mixed with 18% by weight of PEG until get homogenous solution. Furthermore, polysulfone (18% by weight) was stirred into solution for 24 hours under room temperature.

Coagulation bath were made from DMAc (35% by weight), aquadest, and impregnation KCL (0.5% by weight). KCL was used to make water diffusion rate more slowly. Solution was then cast on clean glass plate, then leave it contact with air for 10 seconds. Lastly, thin film on plate was directly immersed in the coagulation bath which prepared before.

Two stage adsorption of pre-treatment. Characterization of peat water were analyzed using DOC ,UV at 245 nm (UV_{254}), $SUVA_{254}$ (UV_{254}/DOC), pH and $KMnO_4$ as parameters. Variation of PAC dosage was added to 200 ml of peat water (80, 160, 240, 320, 400, 480, 560, 640, 720, 800, 880 and 960 mg.L-1) after kept pH 4 constant and stirred under 180 rpm for 120 minute using rotary shaker. This condition refer to previous worked by Aziza [30]. $KMnO_4$ and UV_{254} were tested using titration and UV-Vis, respectively. Optimum dose of PAC was chosen based on the removal.

This optimum dose then used to applied on the next step. In two stage adsorption, PAC was gradually added in two steps by variation of dose ratio (1/4:3/4); (1/3:2/3); (1/2:1/2); (2/3:1/3) of optimum dose. On the first step, ¼ of optimum dose was mixed into peat water (pH 4) under 180 rpm for 60 minutes. A treated water then filtered by a filter paper before continue to the second step. After that, ¾ of optimum dose was added again for the second time under same condition (180 rpm, 60 minutes). Repeat it for other dose ratio. Optimum dose ratio was obtained.

Adsorption UF membrane performance. For filtration tests, new membrane were used in all cases. The water flux of aquadest was tested to know the pure water permeability as well as PAC+aquadest to investigated the effect of PAC without NOM presence. At the beginning, optimum PAC of dose ratio was added to peat water as pre-treatment. Furthermore, a peat water was flowed through UF membrane (**Fig 1**). The experiments were carried out with dead end system in varied pressure (1; 1.5; 2; 2.5; and 3 bar) for 1 hour.

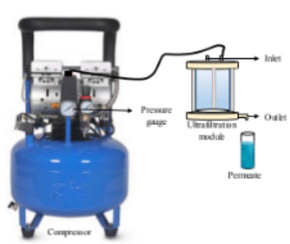

Figure 1. Ultrafiltration set-up

The fluxes was calculated by the following equation (Eq. 1):

$$J = \frac{v}{A \times t} \tag{1}$$

Where J is water flux ($L.m^{-2}.h^{-1}$), V is Volume (L), A is membrane surface area (m^2) and t is time (hour) Rejection of $KMnO_4$ and UV_{254} were determined by the following equation (Eq.2):

$$R = \left(1 - \frac{c_p}{c_f} \times 100\%\right) \tag{2}$$

R is removal efficiency (%), Cp is permeate concentration, and Cf is feed concentration.

Results and Discussion

Peat water characteristics. High organic and low pH of peat water are presented in **Table 1**. So this water is basically not suitable to be consumed [30]. Further, to understand membrane fouling, some parameter such as Dissolved Oxygen Carbon (DOC), UV_{254}, and $SUVA_{254}$ are important to know. DOC as measure of NOM. UV_{254} is good to represent aromatic character on NOM [31]. While, $SUVA_{254}$ (DOC divided by UV_{254}) is known to provide NOM distribution as hydrophobic or hydrophilic, low or high molecular weight. As summarized in table 3.1, according to Edzwald and Tobiason [32] $SUVA_{254}$ values between 2-4 L mg^{-1} m^{-1} indicating this peat water has mixture of hydrophilic and hydrophobic.

Table 1. Peat water characteristics

Parameter	Unit	Value
pH	-	6.3
DOC	mg/L	36.4
UV_{254}	1/Cm	0.98
$KMnO_4$	mg/L $KMnO_4$	120.08
$SUVA_{254}$	L/mg.m	2.68

Two stage adsoprtion. During the experiment, optimum dose was observed in **Fig 2** before a peat water passed through membrane. It shows the removal efficiency of KMnO4 and UV254 tend to be constant after PAC dose increase (>720 $mg.L^{-1}$). It is because the adsorption does not run optimally when too many cation of PAC exist known as restabilization process. In addition, on low of PAC dose (80-720 $mg.L^{-1}$) higher removal efficiency of $KMnO_4$ was found than UV254. This results indicated that PAC has good performance to remove the total of organic but beyond 800-960 $mg.L^{-1}$ the removal of hydrophobic fraction increased immediately. PAC treatment resulting in a decrease both of hydrophobic and hydrophilic fraction [12, 33]. Because of this 800 $mg.L^{-1}$ was chosen for optimum dose.

Furthermore, 800 mg.L^{-1} of PAC dose was added in two steps. As given by **Fig 3,** the ratio of dose 3/4:1/4 result in a higher removal efficiency for $KMnO_4$ and UV_{254}. It means put a large of PAC dose at the first step then later on, give much smaller dose is more effective on NOM removal. This finding also found on Chairuddin [15] and Pradista [34] work. Two stage adsorption can maximize the removal.

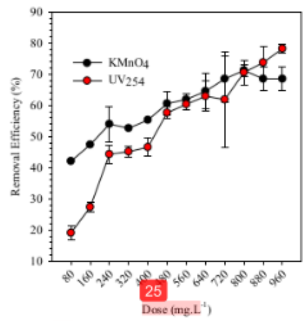

Figure 2. Effect of PAC adsorption on organic removal.

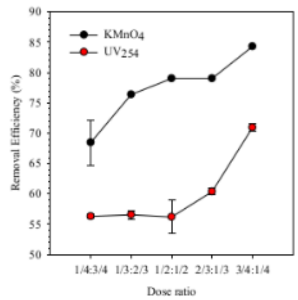

Figure 3. Effect of adsorption two stage using 800 mg.L^{-1} of dose optimum on organic removal.

Performance of two stage adsorption-UF PSf . Two stage adsoprtion**. Fig 4** shows the more pressure is given, the higher water fluxes were obtained for aquadest and peat water. The highest water flux of aquadest is 151.24 L.m^{-2}.h^{-1} for 3 bar. This prepared UF PSf can be categorized as ultrafiltration membrane because the permeability is produce within 20-200 L.m^{-2}.h^{-1} [26, 35]. When blank (aquadest+PAC) entered the UF PSf membrane, it delivers 20.3-95.65 L.m^{-2}.h^{-1} of water fluxes. These water fluxes are 54% lower than aquadest. It suggests PAC may impact on reducing water flux. Similar case also reported by Tomaszewska and Mozia [36]. Contrary to the result found by Lin, Lin and Hao [37]. Nevertheless, some studies investigated PAC did not affected on extent of flux decline using hydrophilic UF membrane [38, 39].

Highest water fluxes of peat water is achieve 39.91 L.m^{-2}.h^{-1} (**Fig 4**). The significant flux drop obviously happened until 73% and 58% compare to aquadest and blank for 3 bar, respectively. Before a peat water has entered the membrane module that undergo adsorption treatment. Two stage adsorption added 3/4:1/4 of optimum dose. Overall the fluxes were decrease on each operating pressure. This phenomena has occurred due to polarization concentration. It is when some particles accumulated on the membrane surface and formed a layer on it. Thus, can reduce the UF membrane performance [6, 40]. Also NOM was attached on the top of membrane surface known as cake layer. Cake layer tightly compact and contribute to worse water flux.

In experiment, NOM could act as glue that make particles easily binding and deposited on membrane surface. Moreover, humic acid can change the shape itself and trapped between PAC-membrane and PAC-PAC [41]. Jucker and Clark [42] studied low pH in peat water exacerbates membrane fouling because it raising the membrane and molecules interaction as hydrophobicity in solution increase as well. As a results flux drop was observed. However, two stage adsorption-UF PSf obtained 92.8 and 88.11% of removal efficiency for $KMnO_4$ and UV_{254}, respectively (**Fig 5**). NOM cannot be removed only by using UF alone [38]. By operating UF, lower pressure applied is good on removal. It is because the smaller feed velocity makes particle easy to filter. This results agree with other study reported [43].

To overcome NOM-PAC deposition, pretreatment and backwashing is mostly used [44]. Several parameters such as the structural properties of PAC [45] and membrane type [38, 39] may influence on NOM removal and fouling mitigation. Hence, they need to be considered first.

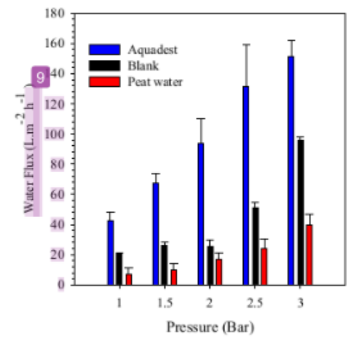

Figure 4. Water fluxes using two stage adsorption-UF PSf

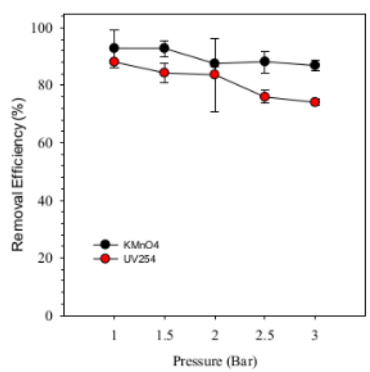

Figure 5. $KMnO_4$ and UV_{254} removal using two stage adsorption-UF PSf

Conclusion

Based on experimental results, the best dose optimum of PAC was obtained 800 mg.L-1 and ratio of PAC dose was 3/4:1/4 for treating peat water. Two stage adsorption-UF PSf provided the range 86.9-92.8% of KMnO4 and 74.1-88.1% of UV_{254}. For the experimental condition of 3 bar, the highest flux was achieve until 39.919 L. m-2 h-1. This study point out that PAC may impact the water fluxes on polysulfone membrane. Although it was successfully remove NOM in the peat water.

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Effect of Two Stages Adsorption as Pre-Treatment of Natural Organic Matter Removal in Ultrafiltration Process for Peat Water Treatment

Mahmud[2,a], Muthia Elma[1,3b*], Erdina Lulu Atika Rampun[1,3c], Aulia Rahma[1,3d], Amalia Enggar Pratiwi[1,3e] , Chairul Abdi[2,f], Raisa Rossadi[2,g]

[1]Chemical Engineering Department, Faculty of Engineering, Lambung Mangkurat University, Banjarbaru, 70714, Indonesia

[2]Environmental Engineering Department, Faculty of Engineering, Lambung Mangkurat University, Banjarbaru, 70714, Indonesia

[3]Material and Membrane Research Group (M[2]ReG), Lambung Mangkurat University, Banjarbaru, 70714, Indonesia

[a]Mahmud@ulm.ac.id, *[b]melma@ulm.ac.id , [c]elarampun@mhs.ulm.ac.id, [d]arahma@mhs.ulm.ac.id [e]aepratiwi@mhs.ulm.ac.id, [f]chairulabdi@ulm.ac.id, [g]raissa.rosadi@gmail.com

Keywords: Adsorption, natural organic matter, fouling, pretreatment, ultrafiltration

Abstract. Natural Organic Matter (NOM) content in peat water is a major problem of membrane fouling in ultrafiltration (UF). For that, two stages adsorption as pre-treatment was employed to minimize the membrane fouling of NOM content. This research was carried out to investigate the effect of two stages adsorption on ultrafiltration performance for NOM removal that remains in peat water. This method was using powdered activated carbon (PAC) dosage of 80, 160, 240, 320, 400, 480, 560, 640, 720, 800, 880 dan 960 mg.L^{-1}. Then, Polysulfone (Psf) material was employed for Ultra filtration process. Membrane was applied in a dead-end mode with various operating pressure (1; 1.5; 2; 2.5; 3 bar). As a results, the optimum dose of PAC was 800 mg L-1 with dosage ratio of 3/4:1/4. Two stages adsorption-UF PSf provided the range from 86.9 to 92.8% of $KMnO_4$ and 74.1-88.1% of UV_{254}. For the experimental condition of 3 bar, the highest flux was achieved up to 39.919 L h^{-1}.m^{-2}.

Introduction

Peat water is stored in a peatland and can be found in temperate zone. Amount of natural organic matter (NOM) is present in peat water include humic acid and acidic as well [1]. In general, NOM can be divided into three fraction: hydrophobic (dissolved organic carbon with larger molecular weight), hydrophilic (smaller molecular weight such as: polysaccharides, amino acid, protein and etc) and transphilic (molecular weight between hydrophobic and hydrophilic) [2, 3]. Hence, it is important to treat a peat water.

Ultrafiltration (UF) is an alternative technology to improve water quality [4]. Nevertheless, membrane fouling is still unavoidable problem [5, 6]. Fouling is occurred when foulant deposit on membrane surface or block the pore. It can make a flux drop and lowered membrane performance. In a previous study shows NOM can cause fouling in UF membrane. Although hydrophilic fractions have less impact on water quality, but studies show large size molecules of hydrophilic NOM have greatly main contribute to fouling [7]. Many methods have been reported to minimize the fouling such as photocatalytic [8], oxidation and ozonation [9], coagulation-flocculation [10], and adsorption [11]. Among them, adsorption using activated carbon good to removes hydrophilic NOM [12, 13].

Adsorption of NOM by activated carbon can be pre-treatment [14]. To increase efficiency of NOM adsorption, two stage adsorption using powdered activated carbon (PAC) can be applied. Two stage adsorption process worked by divided adsorbent capability to transfer adsorbate to adsorbent surface itself. It would maximize efficiency removal and required lower dosage rather than one stage adsorption [15]. However, some researches still have pros and cons about PAC effect on membrane fouling Tansakul, Laborie and Cabassud [16] and Campinas and Rosa [17] have investigated PAC as pre-treatment reduce membrane fouling which caused by NOM. In other hand, many researches also found different results. Combination between PAC and NOM lead to membrane fouling more severe [18-20].

Polysulfone has choosen as polymer because it have highly strength structure on high temperature and chemical resistant [21]. But polysulfone membrane has hydrophobic properties and vulnerable to NOM fouling [22, 23]. So, PEG additive is added to enhance membrane selectivity [24] . Several studies have treat peat water using cellulose acetate [25, 26] and polysulfone membrane [27-29].
In the present work, two stage adsorption with PAC as pre-treatment is carried out to investigated it is the effect on UF PSf performance. Flat sheet of UF membranes were varied at 1-3 bar. Further, $KMnO_4$ and UV_{254} rejection are determined to represent organic and NOM.

Materials and Methods

Materials. A peat water was collected in KM 17 Banjar regency, South Kalimantan. Polysulfone (Merck), N,N-dimethylacetamide (DMAc) (Merck), Polyethylene Glycol 600 (Merck), KCL 0.5% (Merck), acetone 70% (Merck), H2SO4, NaOH (Emsure), oxalic acid (Merck), aquadest, and PAC (Merck), TOC analyzer (Shimidzu), UV-vis, pH meter (Hanna).

UF membrane synthesis. Thin film were prepared using phase inversion technique. Firstly, 64% by weight of DMAc was mixed with 18% by weight of PEG until get homogenous solution. Furthermore, polysulfone (18% by weight) was stirred into solution for 24 hours under room temperature.

Coagulation bath were made from DMAc (35% by weight), aquadest, and impregnation KCL (0.5% by weight). KCL was used to make water diffusion rate more slowly. Solution was then cast on clean glass plate, then leave it contact with air for 10 seconds. Lastly, thin film on plate was directly immersed in the coagulation bath which prepared before.

Two stage adsorption of pre-treatment. Characterization of peat water were analyzed using DOC ,UV at 245 nm (UV_{254}), $SUVA_{254}$ (UV_{254}/DOC), pH and $KMnO_4$ as parameters. Variation of PAC dosage was added to 200 ml of peat water (80, 160, 240, 320, 400, 480, 560, 640, 720, 800, 880 and 960 mg.L-1) after kept pH 4 constant and stirred under 180 rpm for 120 minute using rotary shaker. This condition refer to previous worked by Aziza [30]. $KMnO_4$ and UV_{254} were tested using titration and UV-Vis, respectively. Optimum dose of PAC was chosen based on the removal.

This optimum dose then used to applied on the next step. In two stage adsorption, PAC was gradually added in two steps by variation of dose ratio (1/4:3/4); (1/3:2/3); (1/2:1/2); (2/3:1/3) of optimum dose. On the first step, ¼ of optimum dose was mixed into peat water (pH 4) under 180 rpm for 60 minutes. A treated water then filtered by a filter paper before continue to the second step. After that, ¾ of optimum dose was added again for the second time under same condition (180 rpm, 60 minutes). Repeat it for other dose ratio. Optimum dose ratio was obtained.

Adsorption UF membrane performance. For filtration tests, new membrane were used in all cases. The water flux of aquadest was tested to know the pure water permeability as well as PAC+aquadest to investigated the effect of PAC without NOM presence. At the beginning, optimum PAC of dose ratio was added to peat water as pre-treatment. Furthermore, a peat water was flowed through UF membrane (**Fig 1**). The experiments were carried out with dead end system in varied pressure (1; 1.5; 2; 2.5; and 3 bar) for 1 hour.

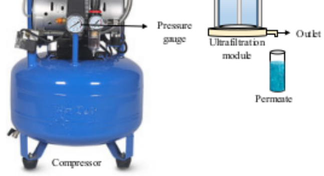

Figure 1. Ultrafiltration set-up

The fluxes was calculated by the following equation (Eq. 1):

$$J = \frac{v}{A \times t} \quad (1)$$

Where J is water flux ($L.m^{-2}.h^{-1}$), V is Volume (L), A is membrane surface area (m^2) and t is time (hour) Rejection of $KMnO_4$ and UV_{254} were determined by the following equation (Eq.2):

$$R = \left(1 - \frac{c_p}{c_f} \times 100\%\right) \quad (2)$$

R is removal efficiency (%), Cp is permeate concentration, and Cf is feed concentration.

Results and Discussion

Peat water characteristics. High organic and low pH of peat water are presented in **Table 1**. So this water is basically not suitable to be consumed [30]. Further, to understand membrane fouling, some parameter such as Dissolved Oxygen Carbon (DOC), UV_{254}, and $SUVA_{254}$ are important to know. DOC as measure of NOM. UV_{254} is good to represent aromatic character on NOM [31]. While, $SUVA_{254}$ (DOC divided by UV_{254}) is known to provide NOM distribution as hydrophobic or hydrophilic, low or high molecular weight. As summarized in table 3.1, according to Edzwald and Tobiason [32] $SUVA_{254}$ values between 2-4 L mg^{-1} m^{-1} indicating this peat water has mixture of hydrophilic and hydrophobic.

Table 1. Peat water characteristics

Parameter	Unit	Value
pH	-	6.3
DOC	mg/L	36.4
UV_{254}	1/Cm	0.98
$KMnO_4$	mg/L $KMnO_4$	120.08
$SUVA_{254}$	L/mg.m	2.68

Two stage adsoprtion. During the experiment, optimum dose was observed in **Fig 2** before a peat water passed through membrane. It shows the removal efficiency of KMnO4 and UV254 tend to be constant after PAC dose increase (>720 $mg.L^{-1}$). It is because the adsorption does not run optimally when too many cation of PAC exist known as restabilization process. In addition, on low of PAC dose (80-720 $mg.L^{-1}$) higher removal efficiency of $KMnO_4$ was found than UV254. This results indicated that PAC has good performance to remove the total of organic but beyond 800-960 $mg.L^{-1}$ the removal of hydrophobic fraction increased immediately. PAC treatment resulting in a decrease both of hydrophobic and hydrophilic fraction [12, 33]. Because of this 800 $mg.L^{-1}$ was chosen for optimum dose.

Furthermore, 800 mg.L^{-1} of PAC dose was added in two steps. As given by **Fig 3,** the ratio of dose 3/4:1/4 result in a higher removal efficiency for $KMnO_4$ and UV_{254}. It means put a large of PAC dose at the first step then later on, give much smaller dose is more effective on NOM removal. This finding also found on Chairuddin [15] and Pradista [34] work. Two stage adsorption can maximize the removal.

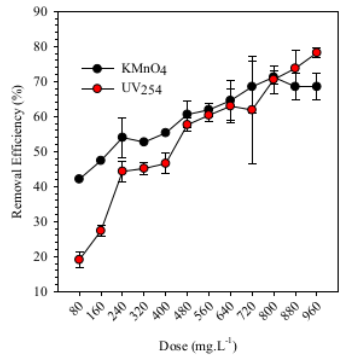

Figure 2. Effect of PAC adsorption on organic removal.

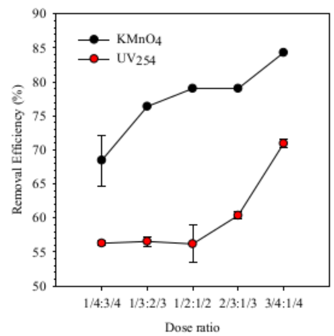

Figure 3. Effect of adsorption two stage using 800 mg.L^{-1} of dose optimum on organic removal.

Performance of two stage adsorption-UF PSf . Two stage adsoprtion**. Fig 4** shows the more pressure is given, the higher water fluxes were obtained for aquadest and peat water. The highest water flux of aquadest is 151.24 L.m^{-2}.h^{-1} for 3 bar. This prepared UF PSf can be categorized as ultrafiltration membrane because the permeability is produce within 20-200 L.m^{-2}.h^{-1} [26, 35]. When blank (aquadest+PAC) entered the UF PSf membrane, it delivers 20.3-95.65 L.m^{-2}.h^{-1} of water fluxes. These water fluxes are 54% lower than aquadest. It suggests PAC may impact on reducing water flux. Similar case also reported by Tomaszewska and Mozia [36]. Contrary to the result found by Lin, Lin and Hao [37]. Nevertheless, some studies investigated PAC did not affected on extent of flux decline using hydrophilic UF membrane [38, 39].

Highest water fluxes of peat water is achieve 39.91 L.m^{-2}.h^{-1} (**Fig 4**). The significant flux drop obviously happened until 73% and 58% compare to aquadest and blank for 3 bar, respectively. Before a peat water has entered the membrane module that undergo adsorption treatment. Two stage adsorption added 3/4:1/4 of optimum dose. Overall the fluxes were decrease on each operating pressure. This phenomena has occurred due to polarization concentration. It is when some particles accumulated on the membrane surface and formed a layer on it. Thus, can reduce the UF membrane performance [6, 40]. Also NOM was attached on the top of membrane surface known as cake layer. Cake layer tightly compact and contribute to worse water flux.

In experiment, NOM could act as glue that make particles easily binding and deposited on membrane surface. Moreover, humic acid can change the shape itself and trapped between PAC-membrane and PAC-PAC [41]. Jucker and Clark [42] studied low pH in peat water exacerbates membrane fouling because it raising the membrane and molecules interaction as hydrophobicity in solution increase as well. As a results flux drop was observed. However, two stage adsorption-UF PSf obtained 92.8 and 88.11% of removal efficiency for $KMnO_4$ and UV_{254}, respectively (**Fig 5**). NOM cannot be removed only by using UF alone [38]. By operating UF, lower pressure applied is good on removal. It is because the smaller feed velocity makes particle easy to filter. This results agree with other study reported [43].

To overcome NOM-PAC deposition, pretreatment and backwashing is mostly used [44]. Several parameters such as the structural properties of PAC [45] and membrane type [38, 39] may influence on NOM removal and fouling mitigation. Hence, they need to be considered first.

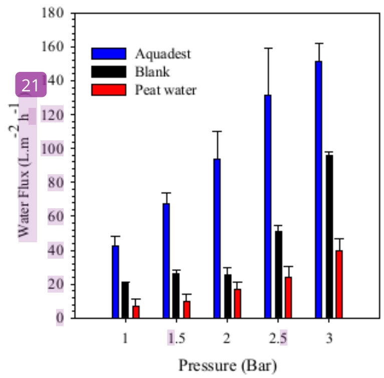

Figure 4. Water fluxes using two stage adsorption-UF PSf

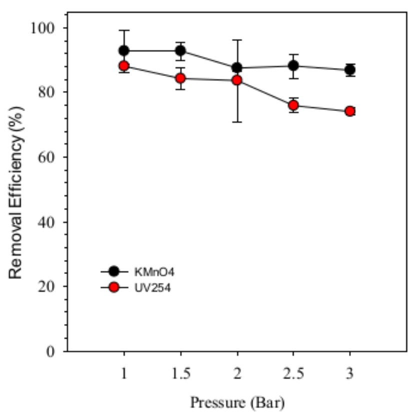

Figure 5. $KMnO_4$ and UV_{254} removal using two stage adsorption-UF PSf

Conclusion

Based on experimental results, the best dose optimum of PAC was obtained 800 mg.L-1 and ratio of PAC dose was 3/4:1/4 for treating peat water. Two stage adsorption-UF PSf provided the range 86.9-92.8% of KMnO4 and 74.1-88.1% of UV_{254}. For the experimental condition of 3 bar, the highest flux was achieve until 39.919 L. m-2 h-1. This study point out that PAC may impact the water fluxes on polysulfone membrane. Although it was successfully remove NOM in the peat water.

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